With the exception of a limited area on our Pacific coast, there is probably no section of the United States where yearly extremes would, as a rule, fall within the limits. A fairer idea of the variability of temperature is obtained from a comparison of records for corresponding hours. This shows a difference of 23° between the highest and the lowest temperatures recorded at noon and a variation of 16° in the 4 a. m. temperatures. The mean of the warmest month at Baguio is 6.5° lower than the mean of the coldest month at Manila.

The invalid would find the chief drawback to Baguio in the fog, cloud, and rain, which are excessive during the rainy season (May to December), and are of course accompanied by a high relative humidity. A record of 203 foggy days in the year is at first thought somewhat appalling, but is modified by the fact that the fog occurred, for the most part, during the night hours. The report does not explain just what constitutes a "fog," nor does it state whether all of the fogs recorded actually enveloped the observing station. The volume is commendable as to its tabular and graphical presentation and is a welcome addition to Philippine climatology.

SOME PECULIARITIES IN FROST FORMATION OVER THE COAST REGION OF SOUTH CAROLINA.

By L. N. JESUNOFSKY, Local Forecast Official, Charleston, S. C., dated Nov. 19, 1902.

Among the chief industries developed at Charleston, S. C., and on the sea islands contiguous thereto, in recent years, are the cultivation of asparagus, beans, cabbages, beets, onions, cucumbers, peas, potatoes, squashes, and other vegetables late in autumn, late in winter, and early in spring for shipment to market in the larger cities, where brisk demands are met by eager produce dealers and where the large yields of these products bring good prices. Truck farming has reached large proportions in this section; the acreage is now double the area of that cultivated but a few years ago. Large tracts of wooded lands are at present being cleared to meet the requirements of this widely expanding industry.

The writer has been intimately acquainted with the truck growing interests in and around Charleston during the past decade, since his connection with the Weather Bureau has brought him into close business relations with the farmers. In the discussions of crop growth and the effect of abnormal temperature and weather changes thereupon, reference has almost invariably been made to the pecularities in frost formation upon the farms and truck gardens. One resident states that were it not for the fact that numerous patches of vegetables are unharmed while others are injured in the same field during the occurrence of frost, the matter would not receive the attention it deserves, since many suppose frost to form uniformly upon vegetation irrespective of physical conditions and surroundings. The main features of this somewhat complex phenomenon, as related by the said resident are: 1, frost spots, of both large and small dimensions; 2, alternate scorching of plants equally exposed, and, 3, the destruction of certain fields containing beans, peas, cabbages, etc., upon one plantation and the apparent safety of the same kind of plants in another portion or an adjoining plantation. The farms in the vicinity of Charleston are quite level; a few are slightly undulating but not to such a great extent as would by cold air drainage serve as a protection against frost on the more elevated portions thereof; consequently this slight unevenness of the land need not be taken into consideration in this discussion.

It is not my purpose in this paper to discourse upon frost warnings, the means and methods of protection against frost, nor the causes which tend to produce frost, but merely to state the peculiar effects of frost formation along the coastal region of South Carolina as I have found them.

The phenomena were first noted early in the fifties and have engaged the earnest and thoughtful attention of many residents of this section ever since. Although discussed from various phases and standpoints, no one has up to the present offered any reasonable explanation of the cause of the three features above enumerated. Some of my colleagues, located at stations along the South Atlantic and Gulf coasts, may possibly have noted the same conditions or had their attention attracted thereto. It seems, however, that several gentlemen of marked scientific attainments, residing in the vicinity of Charleston, have pursued an unbroken series of investigations along this line for a number of years without having arrived at any satisfactory conclusions. Among the most distinguished of these was the late Rev. William Mueller, D. D., pastor of the St. Matthews Church, of Charleston, a botanist and biologist of considerable merit. From him it was learned that the staple crops of this section were subject to peculiar effects of frost formation. Cases were cited where during the occurrence of frost, both light and heavy in character, certain sections of the fields were burnt outright while in others vegetation was scarcely touched. Many cases were related where the frost appeared in circular patches, ranging in diameter from 3 to 10 feet or more. Somewhat more anomalous than the facts given above, may be noted the unaccountable occurrence of single and alternate plants, arranged in rows, being scorched by frost; yet, withal, those which intervened survived and showed but slight damage. It was also found that truck planted on the eastern side of groves of trees was less injured by frost than that grown on the western side of groves.

Having learned the views of Reverend Dr. Mueller and others, it was determined to pursue a series of investigations at length and to test more fully the accuracy of their observations. Upon the occurrence of frosts of different character within the past few years, the conditions under which they formed were carefully recorded; their effects upon young and tender vegetation were noted; those frosts were studied that were preceded by winds from each point of the compass, except the south point, a wind direction seldom preceding frosts in this locality. The conclusions were not so harmonious as at first hoped. Several of the cases were found to appear just as represented by the residents; others were not sufficiently defined to distinguish between abnormal frost formation and that which occurred ordinarily. With east winds the atmosphere was ladened with decidedly more moisture consequently there could not have been such a copious formation of frost, while with westerly winds the atmosphere contained decidedly less moisture, requiring a lower depression of the dew-point for the precipitation of frost. This relation between light frosts attended by easterly winds and heavy frosts with westerly winds does not, in any manner whatsoever, offer any reasonable theory as to the causation of the peculiar formation of frost in question.

The spring of 1897 was remarkably free from frosts. The only frost formation recorded was on March 28. Mr. L. H. Sahlmann, on Charleston Neck, at Myers post office, had peas, cabbages, and beans growing upon his farm on that date. The place is well exposed and free from trees. The frost injured the plants slightly on the western edge of the farm but on the eastern side there was less damage. The injured plants survived but were much dwarfed; the yield was light. On the western side of the bean patch quite large areas showed drooping leaves of a deep green color; on the southeastern side of the same patch the color of the plants appeared of a much healthier hue. It may be observed here that the stems of the plants were not damaged at all and that the injury to each alternate plant as before mentioned was entirely lacking. No injury was done to the cabbages.

The accompanying tabulated statement of frosts is transcribed from the records of the United States Weather Bureau office, Charleston, S. C., and pertains to all frosts of each

autumn, winter, and spring for the period embracing the years 1897 to 1902. The effects of frost on such produce as was growing at the time are given in the subsequent text:

Frosts in the neighborhood of Charleston, S. C.

Spring frosts.				Autumn and winter frosts.			
Date.	Character.	Minimum temperature.	Wind direction.	Date.	Character.	Minimum temperature.	Wind direction.
		°				°	
1897.				1897.			
March 28	Light	41	n.	November 13	Light	48	ne.
1898.				November 18	Light	45	ne.
March 1	Heavy	39	n.	December 6	Heavy	40	n.
March 6	Light	44	ne.	December 7	Light	44	nw.
April 7	Light	43	n.	December 8	Light	45	w.
1899.				December 15	Heavy	42	w.
March 6	Light	42	nw.	December 16	Heavy	43	nw.
March 7	Killing	28	w.	December 17	Light	45	nw.
March 8	Killing	26	nw.	December 24	Heavy	45	n.
March 9	Light	43	sw.	December 25	Heavy	40	ne.
March 20	Light	42	w.	December 28	Light	40	n.
March 30	Light	47	n.	December 29	Light	40	ne.
April 2	Light	47	ne.	December 30	Heavy	47	sw.
April 5	Light	38	n.	1898.			
April 9	Light	44	nw.	October 27	Light	39	n.
April 10	Light	43	n.	November 1	Light	45	ne.
April 11	Light	45	nw.	November 12	Light	49	n.
1900.				November 20	Light	47	n.
March 2	Heavy	38	nw.	November 25	Heavy	37	n.
March 3	Light	44	n.	November 27	Killing	30	n.
March 4	Heavy	40	n.	1899.			
March 5	Light	47	e.	November 5	Light	48	nw.
March 17	Killing	35	nw.	November 6	Light	50	ne.
March 18	Light	42	ne.	December 5	Heavy	33	sw.
March 22	Light	45	e.	December 6	Killing	37	w.
April 1	Heavy	40	n.	1900.			
April 2	Light	46	sw.	November 9	Heavy	36	nw.
April 5	Light	39	n.	November 10	Heavy	40	ne.
April 6	Light	48	n.	November 11	Light	48	ne.
1901.				November 13	Light	39	w.
March 6	Killing	29	n.	November 14	Light	47	w.
March 8	Light	39	sw.	November 15	Light	50	nw.
March 15	Light	45	w.	November 27	Heavy	39	w.
March 16	Heavy	37	nw.	December 2	Heavy	40	n.
March 17	Heavy	35	nw.	December 5	Light	44	nw.
March 22	Light	43	nw.	December 6	Heavy	42	n.
April 4	Light	44	nw.	December 8	Light	44	nw.
1902.				December 9	Heavy	40	w.
March 3	Light	39	nw.	December 10	Heavy	43	n.
March 7	Light	40	ne.	December 11	Light	45	n.
March 19	Killing	30	n.	December 12	Heavy	39	ne.
April 1	Light	43	w.	December 13	Light	45	n.
April 2	Light	41	w.	December 16	Killing	33	n.
April 9	Light	38	w.	1901.			
				November 7	Light	43	n.
				November 9	Light	51	nw.
				November 15	Heavy	43	nw.
				November 16	Killing	34	n.

Frosts of a killing character were not noted during the autumn and winter of 1897, but they were frequent, light and heavy, after December 6. The first frost of the season formed on November 13, some days later than the average date, and was of an exceeding mild type. The spots so frequently spoken of were quite pronounced in this case. The farm of Mr. James Frampton, on James Island, opposite Charleston, was next visited on November 18, the same day upon which a light frost occurred. Mr. Frampton pointed out to the writer the areas most and least affected in his bean and potato fields. It was found that many portions of the bean patch, ranging in diameter from 5 to 50 feet, were scorched slightly, while in between these circular damaged areas there were many sections apparently untouched. In the potato field like conditions were observed. Both crops were harvested. The beans were mostly all killed outright by a heavy frost on December 6. Those that remained uninjured had been planted near a small grove of oaks and yielded well until December 25, when another heavy frost completed the damage. The potato vines which had but a short time previous appeared in the last stages of blossoming, were injured to such an extent that the young tubers were gathered, shipped, and sold as early Bermudas.

The spring of 1898 was somewhat mild; only three frosts were recorded; that of April 7, the last of the season, was more destructive than those of March 1 and 6. Considerable loss was sustained upon the farm of Mr. E. H. Gadsden, in old St. Andrew's parish. The frost formed early in the morning; it was seen at daybreak, but not after sunrise, although its effects were plainly visible, as was evidenced by the well known sickly look of the plants. This truck farm contains about 500 acres, being surrounded on three sides by forests of prodigious growth, a condition for so large an area, not likely to prevent frost formation. One of the most tender plants is the cucumber, which readily succumbs to the least burning influences of frost. That an idea may be obtained of the expression burnt black, as used by the truck growers of this locality, it may be stated that the "cukes" upon Mr. Gadsden's place really turned very dark in color and appeared much shriveled after the freezing process took place. Fully one-eighth of the crop was uninjured—that is that portion of the cucumber field bordering on the State road, where a double row of large pine and gum trees stand. The cucumber field was replowed on the same day; replanting began the next day; germination took place on the fifth day following. The beans, peas, potatoes, and melons were not damaged very much, except that their growth was greatly retarded. The peculiar effects heretofore mentioned were an accompaniment of the frost of April 7, 1898. Mr. Gadsden remarked that when he arrived on the fields that morning he was of "firmer opinion, than formerly, that some other agencies or forces other than those of frost were at work in assisting nature in its own self destruction." The potato plants showed good stands at the time of the frost. On the northwest side of the field the usual effects were felt again in circular areas. It was noticeable that in some areas the stems of the potato vines that had been touched did not recover so rapidly as in others. To what agency this was attributable can only be conjectured. The peas and beans located far over toward the southeastern edge of the plantation were the least damaged.

Nothing appears so desolate and dreary as a field of agricultural products laid waste by frost in a single night, representing, as it does, an equivalent loss in time, labor, wear and tear of implements, machinery and stock, and the cost of seeds or plants. Such a sight met the gaze of the writer during a trip to the plantation of Mr. John Brannen, in old St. Andrew's parish, across Ashley River, in the suburbs of Charleston, on November 28, 1898. The autumn season of 1898 had been a prosperous one. Four frosts intervened between the date of the first light frost on October 27 and the date of the first killing frost on November 27. The first light frost of October 27 proved somewhat detrimental to the trucking interests, owing to the low minimum temperature attendant thereon. As a whole, the crops of beans, peas, potatoes, and cabbages withstood the damaging effects of these frosts quite well up to the time of the first killing frost as before mentioned. Mr. Brannen had planted a crop of beans comprising upward of some 100 square acres, unusually late. The preceding crop yielded well, was fully harvested, and brought good prices. The last crop had already bloomed and was beginning to bear when a killing frost on November 27, with a minimum temperature of 30°, destroyed the entire acreage outright. At the same time Mr. Brannen had 150 acres of winter cabbages, in the heading stage, which were scorched or injured to such an extent that nearly two months elapsed before they regained their former vitality. He immediately reset the same acreage in young cabbages, which matured in a little less than three weeks after the first or scorched cabbages had fully matured. Somewhat yet more remarkable than this may be mentioned: At the time of the injury to Mr. Brannen's first crop of autumn cabbages, on November 27, a neighbor in an adjoining field on the opposite side of the State road, about 300 feet distant, had set out about 50 acres in young cabbages just two weeks to a day before the first killing frost of the season occurred on November 27. This field of young cabbages was unhurt. Here were much younger plants that did not succumb to the frost

and freezing temperatures, while the older and more matured plants were badly injured, irrespective of the surroundings. Mr. E. Ravanel, who is probably one of the oldest planters in old St. Andrew's parish, has given much attention to the effects of frost upon young and tender vegetables. This gentleman's experience dates from the days of old-style farming, when fertilizers were not in such frequent use. The gentleman stated that he has known whole rows of vegetables to be burnt badly when other rows of the same kind were unscathed and recalled many such cases.

The spring of 1899, while not particularly devoid of low frost temperatures, remained mild up to and including April 20. On April 5, 1899, a heavy frost formed which almost created a financial panic among the farming community. Although advised of the approach of frosts, yet the means and methods of protection against frost have been so expensive to the farmer in late years as to preclude the idea of any further investments for this purpose, consequently the destruction of the crops was widespread. Entire fields were completely annihiliated. Replanting was resorted to and begun immediately, creating such a demand for labor as was scarcely ever equaled before in this section. The crops of the second planting were marketed somewhat earlier than those of the North Carolina and Virginia raisings, and in consequence there was a greater demand, and correspondingly advanced prices prevailed. The frosts subsequent to April 5 were pronounced mild types, and did not materially lessen the yield. In connection with the frequent occurrence of frosts during the spring of 1899 it may be remarked that as the subject was more generally discussed among the planters of St. Andrew's and Christ Church parishes, on Charleston Neck, James Island, Wadmalaw Island, Youngs Island, and Edisto Island, S. C., it followed that cases in which frost spots formed and alternate plants burnt were more numerously observed. On March 30 and April 10 and 11 there were especial marked characteristics. The writer observed the following somewhat curious phenomenon. It may at first be necessary to describe the conditions under which these frosts formed in order to more fully understand the matter. The light frost of March 30, 1899, was attended by a minimum temperature of 47°, the wind was from the north, and the velocity 5 miles per hour; April 10, 43° north, 14; April 11, 45° northwest, 5.

On March 30 the garden truck belonging to Mr. E. Ravenel, such as peas, potatoes, asparagus, and beans was well out of ground. This farm lies almost level; it is almost entirely surrounded by large forests of native pine, on the western, northern, and eastern sides, with a clean sweep of open country to the southward for one and a half miles. During the frost of March 30, 1899, and in the fields of peas, could be seen in all directions that well known droop among single plants, indicative of frost formation, while, in the same directions, could be seen healthy plants without blemishes of any kind in large numbers. The frost seemingly had formed in circular spots over this as well as over the fields of asparagus, potatoes, and beans. There is another peculiarity in frost formation not previously described, and that is its damaging effect on the asparagus plant. When nipped by frost this plant does in reality turn very black. In cutting open one of these succulent vegetables it was found that the outer shell or skin had undergone some chemical change unknown to the writer. The inner portion, or meat of the plant, was decidedly soft and stringy and the liquid could be squeezed therefrom as if out of a sponge. The general characteristics of the frosts of April 10 and 11 were much the same as those of the frost of March 30.

The spring and autumn of 1900 were fraught with many disasters among the truck farms of this locality; frosts were more frequent than for many years previous thereto and the phenomena noted in this article were frequently seen. The frosts of April 5 and November 9, 1900, were quite destructive in their effects. The writer visited the plantations of Mr. W. F. Kracke and Mr. James D. Croghan, in old St. Andrew's parish, and those of Mr. Robert Nix, Henry D. Williams, and J. S. Horlbeck, in Christ Church parish, at Mount Pleasant, S. C., a suburb of Charleston, and verified the same effects of frost during the spring and autumn of 1901 and the spring of 1902. The truck growers of this locality have become somewhat ingenious. They plant peas and cantaloupes side by side in alternate rows and three feet apart within the same field. In the event of either of the plants becoming badly injured that particular row is turned over by the plow and planting is begun over again within a few inches to the right or left of the rows that were destroyed or injured.

In seeking the cause of the irregular effects of frost formation, some attribute these injuries to the excessive use of fertilizers, and others to the ground water that elevates the temperature of the surface and prevents rapid radiation from the vegetation. The former view is untenable since all lands are covered with fertilizers evenly and alike according to the desired strength required, and it would be an almost physical impossibility to distribute the fertilizers otherwise. With respect to the ground-water theory there can be but one answer. It is known that plants near large bodies of water suffer from frost less than those located over level and dry land. Assuming then that moist air or soil is a better preventative against frost than drier air or soil, something can be said in favor of the ground-water theory. But upon further examination it is found that the lands upon which this peculiar local frost formation took place appeared equally dry or moist for a few feet below, agreeing precisely with climatic conditions. Again, local currents of air, somewhat warmer and more moist than the surrounding bodies of air, may have served to check frost formation to a limited extent and thus caused less damage than at points where the colder air settled. There is a bare possibility that the salt in the air of this section may have had some influence upon the vegetation, thus preventing a deposit of frost upon it. It is known that objects coated with salt require lower temperatures for congelation than those not so coated.

HAWAIIAN CLIMATOLOGICAL DATA.

By CURTIS J. LYONS, Territorial Meteorologist.

GENERAL SUMMARY FOR OCTOBER, 1902.

Honolulu.—Temperature mean for the month, 75.8°; normal, 76.4°; average daily maximum, 81.8°; average daily minimum, 70.3°; mean daily range, 11.5°; greatest daily range, 17°; least daily range, 6°; highest temperature, 84°; lowest, 67°.

Barometer average, 29.969; normal, 29.967; highest, 30.10, 15th; lowest, 29.84, 6th; greatest 24-hour change, that is, from any given hour on one day to the same hour on the next, .07; lows passed this point on the 6th and 25th; highs on the 10th and 15th. The pressure has been even through the month.

Relative humidity average, 74.5 per cent; normal, 71 per cent; mean dew-point, 66.6°; normal, 66.2°; mean absolute moisture, 7.17 grains per cubic foot; normal, 7.05 grains; dew, 11 morning.

Rainfall, 2.59 inches; normal, 2.76 inches; rain record days, 20; normal, 19; greatest rainfall in one day, 1.05, on the 15th; total at Luakaha, 13.12 inches; normal, 11.69 inches; total at Kapiolani Park, 0.73 inch; normal, 1.12 inch.

The artesian well level stood for the month without falling, 32.95 feet above mean sea level. October 31, 1901, it stood at 33.12. The average daily mean sea level for the month was 10.05 feet, the assumed annual mean being 10.00 feet above datum. For October, 1901, it was 10.37. Trade wind days, 21 (7 of north-northeast); normal 22. Average force of wind during daylight, Beaufort scale, 2.1. Average cloudiness, tenths of sky, 3.3; normal, 4.3.

Approximate percentages of district rainfall as compared